TECHNICAL EVALUATION REPORT:

AIRCRAFT UPDATE PROGRAMMES. THE ECONOMICAL ALTERNATIVE?

By

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INTRODUCTION

This SCI Symposium on Aircraft Update Programmes asked a very important and timely question, "Are Update Programmes the Economical Alternative?" The alternative , of course, being a new system development program (such as the Eurofighter or F-22) or replacement program (such as buying new F-16s or C-130s). The reason that this topic is so important and timely is that all NATO members are facing (1) decreasing military budgets, (2) increasing diversity of the threat and (3) all systems are ageing and becoming obsolete. Even though the USSR has become dismembered and no longer poses a single global threat, the regional conflicts and terrorists activities poses a more demanding diverse threat The NATO members are expected to meet this diverse threat with ageing systems and decreasing military budgets.

The symposium was broken into five sessions:

1. Overview and Lessons Learned (Part I)
2. Cockpit
3. Sensors
4. Engine
5. Overview and Lessons Learned (Part II)

The options for the NATO members are the development of a new system, replacement with a new off-the-shelf (OTS) system or the upgrade of the existing system. The upgrade of the existing system can be in the form of:

1. Structural life extension program (SLEP)
2. New engines
3. New avionics
4. New weapons

The symposium addressed the first three but ignored the very important consideration of new weapons. A new weapon can breathe new life into an otherwise obsolete platform. For example, the stand-off cruise missiles currently in development (US JASSM, UK Storm Shadow and the German Taurus) will provide hard target kills without the launch aircraft having to penetrate a heavily defended area.

The decision to pursue a new system development, replace with a new system or upgrade an existing system must consider several factors. One very important consideration is that the development of a new system will cost (non-recurring plus recurring) at least ten times the cost of an upgrade program. Even the recurring cost of replacement with a new OTS system will be more (typically a factor of five) than the upgrade of an existing system since the existing system is a sunk cost. A NATO member must do a very

careful and thorough cost-benefit study before embarking on a new system development program as the risk is high and the cost is great. A critical part of the cost-benefit study is to establish what has rendered the current system obsolete. Is the obsolescence due to (1) new applications, mission or requirements, (2) changing threat, (3) system becoming too expensive to operate, or (4) is the current system just worn out? If the decision of the cost-benefit analysis is to upgrade the existing system there needs to be 10-15 years of airframe life remaining after the the upgrade.

The current situation in NATO is that there are a few new system replacement programs, fewer still new system development programs but many upgrade programs. The symposium audience heard from many of the upgrade programs.

OVERVIEW AND LESSONS LEARNED

Paper #1 by Andrew Kerr (NASA Ames Research Center, Moffett Field, Ca) offered some interesting perspectives on rotorcraft technologies. He pointed out that the technologies for rotorcraft are different than for fixed wing aircraft due to the unsteady and unsymmetrical loadings. He offered a process for deciding between a new system versus an upgrade program, and emphasized that the principle parameter will be cost. The trend for helicopters is that the engine will be upgraded at least once during the aircrafts lifetime. The technology community is making great strides in structures/materials with the potential for significantly improved rotorcraft systems.

Mr. G. LeBretton (Thomson-CSF, France) made an interesting observation on upgrading fighter aircraft in **Paper #7**. Mr LeBretton observed that the following fighter operational needs, can all be met with upgrades to existing fighters:

1. Improved range
2. Multirole capability
3. Decreased attrition (improved survivability)
4. Decreased collateral damage (improved accuracy)
5. Day/night and all weather operation
6. No friendly kills (improved IFF)

Thus, why pay 4 to 5 times more for a new aircraft replacement when the existing fighter fleet can be retrofitted to meet the needs. The author hastens to point out that the fighter upgrade will serve for an additional 12 to 15 years and not the 30 years of a new fighter. This observation is endorsed by the electronics manufacturers who have made avionics upgrades a profitable line-of-business. However, this observation is not in the best interest of the aircraft manufacturers who spend considerable budget to convince their military that the right answer is a new fighter aircraft development.

Paper #13 by E.C. Vaught and L.B. Giles (Bell Helicopter Textron, Ft. Worth, Tx) discussed a systems engineering process for developing a strategy for long-term systems and technology advancement. The paper argued that ground based systems integration solutions must supplant aircraft testing to the maximum extent possible in order to accommodate rapid and economical test results without expending valuable aircraft time. In addition, training for pilots, crews, and maintainers must move to improved ground training systems, such as full flight simulation trainers and non-motion cockpit trainers.

The integration of defensive aids was the topic of **Paper #14** by Dr. Philip Zanker (DERA, Farnborough, UK). He presented a three layered approach to survivability: (1) threat avoidance – route around threats to avoid detection, (2) minimize danger by confusing or suppressing the enemy, and (3) close-in defense by immediate threat warning and terminal countermeasures. The key to self protection is situational awareness. There are four levels integration for the defensive aids:

1. Basic mechanical and electrical – the integration of separate subsystems, each complete with its own set of displays and controls. (least expensive)
2. Integrated Defensive aids suite (IDAS) – integrated within itself with a common means of display and control.
3. IDAS with avionics integration – integration into existing cockpit displays and controls, and weapons and databases

4. DAS within a federated or integrated modular avionic architecture – the defensive aids become an intimate part of the flight avionics suite. (most expensive)

The customer specification will drive the desired level of integration but cost will determine the achieved level.

Paper #15 by Christian Dedieu-Eric Loffler (SAGEM SA) presented an already fielded implementation of an avionics upgrade package developed to offer a modular solution to a wide range of modern operational requirements. The SAGEM SA upgrade concept allows one to match specifications ranging from basics performance enhancement, such as high accuracy navigation for low level flight, up to full multi-role capability with sophisticated air-to-surface weapon delivery and multi-target air-to-air fire control.

UPGRADE PROGRAMS

UH-1/AH-1 Upgrade to the UH-1Y/AH-1Z For the USN/USMC

Three papers from the US addressed the upgrade programs for the USN/USMC UH-1 Huey and AH-1 Cobra helicopters. The **Keynote Address** by Capt J.T. Curtis USN (Program executive Office, AIR ASW Assault & Special Mission Program), **Paper #2** by Alan W. Myers (Technical Director, H-1 Upgrade, Bell Helicopter Textron) and Major Paul Davidovich UCMC (Class Desk, H-1 Upgrade), and **Paper #12** by J.A. Dowell (Litton Guidance and Control systems) discussed the structural, propulsion and avionics upgrades to 180 AH-1 and 100 UH-1 helicopters.

Capt. Curtis pointed out that the USN and USMC plan to reduce their VTOL fleet to the CH-53E, V-22 and the AH-1Z/UH-1Y over the period 2000-2020. Currently the Huey and Cobra are about 20 percent common. The goal of the upgrade program is to increase the commonality to 85 percent. The upgrade program will triple the radius of the AH-1Z with 8 Hellfire missiles. The UH-1Y radius will increase to 133 nm from almost zero for the UH-1 with 8 troops, 4 aircrew and 30 minutes time-on-station.

The improvements to the Cobra helicopter include a new tailrotor and gearbox, electrical system, weapons pylons, hydraulic system, landing gear, crashworthy crew seats, main rotor and transmission, integrated glass cockpit and targeting sight system. In addition, the Cobra has received new GE-T700-401 engines and IR suppressor, airframe mods to provide for increased weight, more survivability and a 10,000 hour fatigue life, an APU and increased fuel capacity for more range. Similarly the Huey has received most of the Cobra improvements plus a 21 inch fuselage stretch into new primary structure. The contract award for the H-1 Upgrade Program was in early FY 1996 and the schedule shows low rate initial production in 2002 for the AH-1Z and 2003 for the UH-1Y.

Helicopter Modernization With Advanced Engines

Paper #18 by Fred Dickens (Rolls-Royce Allison, Indianapolis, In USA) discusses the modernization of current helicopters with engine upgrades. He discusses the re-engine programs for the CH-47 Chinook, OH-58 Kiowa, UH-60 Blackhawk, AH-64 Apache, and Westland Lynx, but spends most of the paper on the US Army UH-1H. The US Army's UH-1H was a good candidate for an engine upgrade since it had substantial airframe life out to 2025. Replacing the T 53 engine in the UH-1H with the T 800 (developed for the US Army RAH-66 Comanche) improves the mission endurance by 50 percent and the range or payload by 58 or 47 percent respectively. Because of the improved RM&S of the T 800 engine, an operator will be able to recover the cost of the re-engining through the savings realized from as few as two T 53 overhauls. The paper also discusses the factors involved in deciding between replacement or upgrade. Replacements are appropriate when the mission need and capability of the replacement is so compelling that upgrades to the existing system are simply cost prohibitive. A decision to extend the life of a system with an upgrade program is appropriate when the mission has remained relatively unchanged and technology is available to directly enhance mission effectiveness.

F-16 A/B Mid-Life Update (MLU) Program

Paper #3 by V.L. Denena (Lockheed Martin Tactical Aircraft Systems Co., Ft. Worth, Texas) addressed the cockpit and avionics upgrade of 360 F-16 A/Bs in the US, Belgium, Norway, Netherlands and Denmark. This MLU Update Program involved a kit development and in-country production effort currently extending from 1990 through 2003. The kits are for block 1/5/10/15 aircraft but could be adapted for block 25/30/40 aircraft. The cockpit upgrades include a WAC HUD, up-front controls, two CMFDs, side-stick throttle, NVG compatible, night operations capable and CCTVS/CAVTR. The avionics upgrades are a digital terrain system, GPS, electronic warfare management system, advanced IFF, APG-66(V)2 radar, improved data modem, modular mission computer and inlet hard points for a FLIR pod or target pod. The depot modification requires complete depaneling of aircraft and teardown of crew station and avionics equipment bays. Approximately six months and 2500-4000 manhours (depending on block number) are required to perform the work. The modification work is well underway and on schedule with approximately 75 aircraft modified to date. The cost/benefit study conducted in the late 1980s concluded that the MLU program cost was substantially less than a new aircraft.

The Tornado IDS Mid-Life Upgrade Programmes

Paper #4 by T. Watkins (British Aerospace) and **Paper #6** by D. Hoffman (Daimler-Benz Aerospace, DASA) addressed the upgrade of the Tornado (Interdicter Strike) with modern avionics. One hundred and forty two British GR-1s are being reconfigured into the GR-4 with the introduction of the following new avionics equipment:

1. New sensors and displays consisting of a FLIR, multi-function displays with digital map, wide-angle HUD, computer symbol generator, video recording system and a computer loading system
2. New armament control system consisting of a stores management system, a weapon interface unit linked to a 1553 databus within a 1760 interface
3. Night vision goggle compatible cockpit
4. Terrain reference navigation/terrain following display/terrain following switching and logic unit/covert radar altimeter

The development work was completed in1998 with production mods scheduled through 2003.

The German Tornado MLU is a two phase program. Phase I scheduled for the year 2000 includes:

1. Enhanced main computer with a new Ada software (ASSTA) and a digital weapon bus
2. Integration of GPS and a laser INS into the navigation system
3. Integration of the GBU 22 and 24 LGBs and the Harm III

Phase II, scheduled for 2004, includes:

1. Integration of colored LCD displays, a digital map, and new EW warning indicators
2. Integration of the new stand-off cruise missile Taurus
3. Integration of an improved radar warning receiver
4. Integration of an enhanced Tornado nose radar
5. Provision for a radar reconnaissance pod

Mirage 2000 Mid-Life Upgrade Programme

Paper #5 by Alain Picard and Laurent Madon (Dassault Aviation) presented the MLU program for the Mirage 2000. The aircraft airframe life is estimated to last through 2020, thus an avionics upgrade offered a cost effective modernization plan. The MLU program will comply with the following criteria:

1. Replace current sensors with state-of-the-art modern sensors with up to date operational performance
2. Replace the current WNDS core system with an open system based on modular avionics architecture allowing, in particular, to separate application software and hardware.

3. Replace the current cockpit with a modern glass cockpit taking benefit of the numerous advantages of the man-machine interface fitted on the Mirage 2000-5.

The target of this mid-life update is to obtain a more modern Mirage 2000 at 80 percent of the cost of a Mirage 2000-5.

Aircraft Life Extension – CC-130 Hercules Avionics Update

Paper #10 by Major Chris Daley (Canadian National Defence Headquarters, Ottawa, Canada) presented the avionics update program for their Hercules transports. The Canadian CC-130 transports had their structural life extended beyond 2010 by earlier SLEP programs, so that an avionics upgrade was a very cost-effective solution for modernization. The CC-130 fleet of 32 aircraft is composed of six different Hercules models, each equipped with a different avionics configuration. It was estimated that the avionics systems would become unsupportable or obsolete by 2010. It was considered essential from an operational and economic standpoint that all aircraft receive a standard and updated avionics suite. The paper presented an excellent discussion of the process and results of the Canadian Department of National Defence cost-benefit analysis. The 32 aircraft have been modified for about $40M (Canadian) in non-recurring and $3M per aircraft.

Cockpit Upgrade For the G222 to C-27J

Paper #11 by Gianluca Evangelisti and Maurizio Spinoni (Alenia Aerospace) described the cockpit modification to the Italian G222 tactical transport to develop the C-27J. The C-27A was a joint development by Alenia and Lockheed Martin building on the rugged G222 design and incorporating new avionics, propulsion and general subsystems. The cockpit upgrades, developed for the C-130J, were incorporated into the C-27A to produce the C-27J. The paper presents a description of the main cockpit features and the process used to select a cockpit configuration that allows optimized operational capabilities while reducing overall development costs.

MH-53J Service Life Extension Program

Paper #23 by Charles Crawford (Georgia Tech Research Institute) and Col. Henry Mason (USAF, Director of SOF System Program Office, Warner Robins AFB, Ga) presented a summary of the air vehicle modifications (largely structural) that were made and the airworthiness qualification flight test program that was conducted to increase the operational gross weight and enhance the structural integrity of the CH-53J. The impact on both vibration and dynamic component retirement times are discussed. The paper includes both technical and cost information to support the cost- benefit analysis for the modernization program. The SLEP was completed in 1990 and increased the helicopters life past 2000 towards the V-22 IOC. The program non-recurring cost was approximately $40M (US) with a unit recurring cost of $2.4M for 41 aircraft.

Canadian CF-188 and CP-140 Service Life Extension Programs

Major Normand Landry (Canadian National Defence Headquarters, Ottawa, Canada) presented a very nice analysis for the selection of SLEP for their CF-188 and CP-140 fleets in **Paper #24.** Canada has decided to perform a structural and systems upgrade on their CF-188 and CP-140 aircraft. These upgrades will allow the aircraft to meet their operational requirements until the first quarter of the next century. The choice for this course of action was based upon option analysis studies. This paper presents the approach taken and the assumptions made for the various option packages studied to reach that conclusion. Avionics packages are readily available OTS and in most cases the decision is based mostly on structural limitations.

Transall C-160 Life extension and Avionics Upgrade Programs

Paper #26 by P. Blumschein (Daimler Chrysler Aerospace) discussed the structural life extension and avionics upgrade programs for the German Transall C-160 transport. Starting in 1984, the C-160 has undergone several structural life extension programs: (1) cold working in the wing area, (2) reinforcement of the wing area, and (3) prevention and corrective measures on the entire airframe. These efforts have extended the airframe life of the aircraft from the original estimate of 1990 to at least 2010. Starting in 1987 an avionics upgrade program has been ongoing continuously to the present. This program has replaced obsolete and hard to support equipment with more modern avionics. A self defense system was installed from 1992 to 1999 consisting of radar warning, chaff/flare dispenser, missile approach warning system and an electronic warfare management system. According to the present planning, the C-160 will be in service to 2018. Since the aircraft first entered service in 1967, this is an average service life of more than 50 years. For this aircraft the cost of the upgrade programs is less than 20 percent of a new aircraft purchase. Thus, the upgrade programs are indeed a cost-effective alternative for the Transall C-160.

USAF Bomber Upgrade Program

During the panel discussion, information about the USAF bomber road map was presented. The USAF has concluded that they will need a new long range, large payload, rapid response bomber by 2037. This means that the 76 B-52s, 93 B-1s and 21 B-2s will need to provide the bomber fleet mission until that date. It should be noted that the year 2037 would mean approximately 80 years of service for the B-52. The aircraft, for the most part, have the airframe life to extend to 2037. However, the USAF will embark on a three phase upgrade program, mostly modern avionics, displays and defensive aids. The USAF has programmed $2.3B (US) for a three phase upgrade plan:

1. $923M in 2000 to 2010
2. $678 M in 2006 to 2015
3. $685M in 2015 to 2025

All three aircraft will be given precision, stand-off capability with the integration of the US JSOW and JASSM weapons. A new bomber development program would be initiated no later than 2013.

SUMMARY AND OBSERVATIONS

With regard to the original symposium question, "Are aircraft update programmes the economical alternative?", the answer is a resounding YES. With a new aircraft development program costing at least a factor of 10 more than an upgrade program, it is difficult to make a case for a new aircraft development. Oft time the new aircraft program is driven by national pride and pressure from the prime aerospace companies, rather than the evidence from an honest and thorough cost-benefit study. Even replacing the existing aircraft with new off-the-shelf aircraft will cost a factor of 5 or more than upgrading the existing aircraft. The shortcoming with upgrading an existing aircraft is that its useful life is extended another perhaps 20 years at most, whereas a new aircraft would give double the life.

The symposium did not address upgrading an existing aircraft with a new weapon. This important upgrade option would make a good follow-on symposium.

Several of the papers were pure sales pitches for supplier products. Symposia such as this one are not the forums for marketing presentations.